Original Article

High-Frequency Hearing Loss Amongst Smart Mobile Phone Users: A Case–Control Study

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Abstract

Background: In past 20 years, there is increase in mobile phone users from 12.4 million to about 5.6 billion i.e 70 % of the world's population.[1] Electromagnetic radiations emitted from mobile phone damages inner ear, cochlea and outer hair cells of inner ear and auditory pathway (AP).[2] **Materials and Methods:** Case control study. Group 1, N=30 subjects, using mobile smart phones since past 1-5 years and exposure time more than 2 hours per day. Group II included 30 subjects, using mobile smart phones for more than 5 years and exposure time more than 2 hours per day. Headache, tinnitus, or sensations of burning around phone-using were excluded. Brainstem auditory evoked potential (BAEP) done. Student Unpaired t test was used for analysis and chisquare test. **Results:** Mean ± SD of absolute latencies (AL) of Brainstem evoked response auditory. (BERA) waves III, V and all interpeak latencies at 80 dB and 4,6,8 KHz in group 2 were delayed and significant as compared to group 1.All parameters were highly significant at 8KHz as compared to 4KHz in group 2. **Conclusion:** Brain stem evoked response audiometry (BERA) detects hearing loss in smart mobile phone using subjects at higher frequencies i.e at 8 KHz early. Hence central neural axis involvement can be detected early by BERA.

Keywords: Auditory pathway, brain stem auditory evoked potential, brain stem evoked response audiometry, interpeak latencies

Résumé

Contexte: Au cours des 20 dernières années, le nombre d'utilisateurs de téléphones mobiles est passé de 12,4 millions à environ 5,6 milliards, soit 70 % de la population mondiale.[1] Les rayonnements électromagnétiques émis par les téléphones portables endommagent l'oreille interne, la cochlée et les cellules ciliées externes de l'oreille interne et des voies auditives (PA).[2] **Matériels et méthodes:** étude cas-témoins. Groupe 1, N = 30 sujets, utilisant des téléphones intelligents mobiles depuis 1 à 5 ans et temps d'exposition supérieur à 2 heures par jour. Le groupe II comprenait 30 sujets, utilisant des téléphones portables intelligents depuis plus de 5 ans et ayant une durée d'exposition supérieure à 2 heures par jour. Les maux de tête, les acouphènes ou les sensations de brûlure lors de l'utilisation du téléphone ont été exclus. Potentiel évoqué auditif du tronc cérébral (BAEP) réalisé. Le test t non apparié de Student a été utilisé pour l'analyse et le test du chi carré. **Résultats:** Moyenne ± écart-type des latences absolues (AL) de la réponse auditive évoquée du tronc cérébral. (BERA) les ondes III, V et toutes les latences interpics à 80 dB et 4,6,8 KHz dans le groupe 2 étaient retardées et significatives par rapport au groupe 1. Tous les paramètres étaient hautement significatifs à 8 KHz par rapport à 4 KHz dans le groupe 2. **Conclusion:** L'audiométrie à réponse évoquée du tronc cérébral (BERA) détecte la perte auditive dans un téléphone mobile intelligent en utilisant des sujets à des fréquences plus élevées, c'est-à-dire à 8 KHz plus tôt. Par conséquent, l'implication de l'axe neural central peut être détectée précocement par BERA.

Mots-clés: Voie auditive, potentiel auditif évoqué du tronc cérébral, audiométrie de réponse évoquée du tronc cérébral, latences interpics

Introduction

Radiations emitted from mobile phones are at 900 MHz and they receive microwave radiation at 1800 MHz.[1] Mobile

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phone causes headaches, altered cognitions and neural activity, disturbed sleep, warmth sensations around the ear[2] and mobile phones held close to the ear may damage the auditory system.[3]

In response to a click stimulus by headphones, brainstem evoked response audiometry (BERA), a noninvasive test records potentials from the brain stem by placing surface electrodes at the mastoid process and vertex of the scalp.[4] Brain stem function assessment by other tests is tedious work. BERA diagnoses defects from cranial nerve VIII to the auditory cortex.[5] The BERA waves I–VII were recorded within 10-ms.[6] Few studies have been available about mobile smartphones exposure by BERA. Hence, the aim is to study the impact of mobile smartphone exposure on the central auditory pathway by BERA.

Aim

The aim is to study BERA in subjects using mobile smartphones at 4, 6, and 8 KHz, frequencies.

Materials and Methods

Ethical committee clearance from the institute was taken. Written informed consent was taken from everyone. It was a case–control study done between October 2022 and June 2023 in the Department of Physiology, IGIMS, Patna.

Inclusion criteria

Sixty individuals between 18 and 30 years were enrolled. Group I had 30 individuals, who used mobile smartphones for 1–5 years and more than 2 h/day. Group II had 30 individuals, who used mobile smartphones for more than 5 years for more than 2 h/day.

The hypothesis was waves of BERA and interpeak latency would be delayed in individuals using smartmobile phones for a prolonged duration. For sample size calculation, artificial intelligence therapy statistics beta was used. The large effect size was (0.8) and the alpha value was 0.05.[6] Eighty percentage power was considered,[7] and 52 individuals were required (26 in each group).

Exclusion criteria

Epileptics, smokers, any kind of trauma to the ear, neuroleptics, antidepressant, psychotic drugs, COVID-positive subjects, drug abuse, chronic diseases such as diabetes, hypertension, arrhythmia, family history of hearing disorder, taking furosemide, and noise-induced hearing loss were not included in the study.

Rinne's test and Weber's tests were performed. Weight in kg and height in cm were measured. Body mass index was calculated (kg/m^2).[8]

Procedure

Disc electrodes were placed as (1) Active electrode, at the mastoid or earlobe; (2) Reference electrode, at the vertex of the skull; and (3) Ground electrode, at the forehead in the midline. The right dominant ear was tested and masking of the other opposite ear with 40 dB white noise was done. Acoustic click stimulus using headphones at 80 dB and 4, 6, and 8 KHz frequencies was introduced.[5] Two readings were recorded to reproduce BERA waves and interpeak interval. The filter was set between 100 and 3000 Hz.[6] Two thousand sweeps at 1 ms/div with 0.5 μv/div sensitivity were recorded. Impedance was kept below 5 kΩ.

Statistical analysis

Data analyzed by GraphPad Quickcals Student's unpaired *t*-test and social science statistics online Chi-square test. mean values and standard deviation of BERA waves and interpeak latencies (IPL) were compared between the two groups. $P < 0.05$ was statistically significant and $P < 0.0001$ was highly significant.

Results

BERA waves were compared between the two groups. Mean data of I, III, and V waves and IPL I–III, III–V, and I–V of Group 1 at 80 dB, 4 KHz were 1.60 (0.20), 3.52 (0.15), 5.43 (0.17), 1.78 (0.23), 1.93 (0.23), and 3.78 (0.34) and Group 2 were 1.62 (0.21), 3.65 (0.15), 5.60 (0.31), 2.00 (0.26), 2.04 (0.18), and 3.98 (0.41) (ms), respectively. Wave I value was nonsignificant ($P > 0.05$). The mean values of Group 2 were statistically significant ($P < 0.05$). Wave III, I–III interpeak latency reported high significance ($P < 0.001$) [Table 2 and Figure 1].

Mean data of waves I, III, V and IPL I–III, III–V, and I–V of Group 1 at 80 dB 6 KHz were 1.62 (0.21), 3.53 (0.17), 5.44 (0.25), 1.81 (0.17), 1.94 (0.28), and 3.80 (0.38),

Table 1: Demographic data

Parameters	Group 1 ($n=30$)	Group 2 ($n=30$)
Age (years)	22.2 (3.2)	22.8 (1.7)
Weight (kg)	51.13 (1.61)	50.17 (1.86)
Height (cm)	157.87 (1.89)	156.72 (1.23)
BMI	20.7 (3.03)	20.5 (2.13)

BMI=Body mass index

Table 2: Brain stem evoked response audiometry waves and interpeak latencies comparison at 80 dB and 4 kHz in mobile smartphone usage <5 years and mobile phone usage >5 years

	Group 1 ($n=30$), mean±SD (ms)	Group 2 ($n=30$), mean±SD (ms)	*P*
Waves			
I	1.60±0.20	1.62±0.21	0.70 (NS)
III	3.72±0.20	3.84±0.22	0.03*
V	5.59±0.19	5.70±0.23	0.04*
Interpeak latency			
I–III	1.8 7±0.10	1.97±0.20	0.01*
III–V	1.88±0.22	2.02±0.29	0.03*
I–V	3.79±0.21	3.91±0.22	0.03*

NS=Nonsignificant, *=Significant, SD=Standard deviation

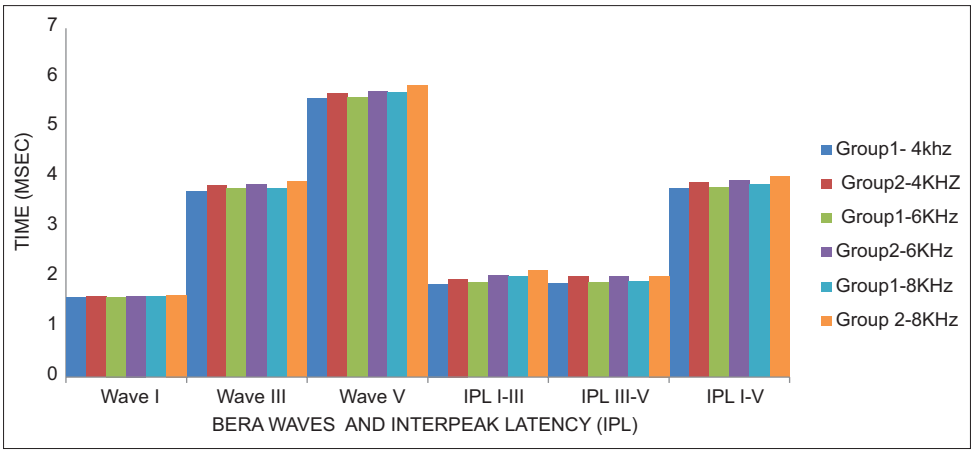

Figure 1: Brain stem evoked response audiometry waves and interpeak latencies comparison at 80 dB and 4, 6, 8 KHz in mobile smartphone users. Group 1 – Mobile smartphone usage <5 year, Group 2 – Mobile smartphone usage >5 years. BERA = Brain stem evoked response audiometry [Tables 2-4]

Table 3: Brain stem evoked response audiometry waves and interpeak latencies comparison at 80 dB and 6 kHz in mobile smartphone usage <5 years and mobile phone usage >5 years

	Group 1 (n=30), mean±SD (ms)	Group 2 (n=30), mean±SD (ms)	*P*
Waves			
I	1.61±0.20	1.63±0.10	0.62 (NS)
III	3.78±0.12	3.86±0.10	0.03*
V	5.61±0.21	5.74±0.20	0.01*
Interpeak latency			
I–III	1.89±0.21	2.04±0.20	0.006**
III–V	1.90±0.19	2.02±0.20	0.02*
I–V	3.80±0.20	3.95±0.21	0.006**

NS=Nonsignificant, **=Highly significant, *=Significant, SD=Standard deviation

Table 4: Brain stem evoked response audiometry waves and interpeak latencies comparison at 80 dB and 8 kHz in mobile smartphone usage <5 years and mobile phone usage >5 years

	Group 1 (n=30), mean±SD (ms)	Group 2 (n=30), mean±SD (ms)	*P*
Waves			
I	1.62±0.12	1.65±0.10	0.29 (NS)
III	3.79±0.19	3.92±0.20	0.01*
V	5.71±0.15	5.85±0.20	0.003**
Interpeak latency			
I–III	2.02±0.18	2.14±0.16	0.008**
III–V	1.91±0.19	2.03±0.19	0.01*
I–V	3.86±0.20	4.02±0.22	0.004**

NS=Nonsignificant, **=Highly significant, *=Significant, SD=Standard deviation

whereas Group 2 were 1.71 (0.2), 3.66 (0.2), 5.71 (0.37), 2.01 (0.27), 2.07 (0.21), and 4.07 (0.37) (ms), respectively. Wave I value was nonsignificant ($P > 0.05$), mean data reported statistically high significance ($P < 0.001$) in Group 2 and III–V latency was significant in Group 2 ($P < 0.05$) [Table 3 and Figure 1].

Waves I, III, V and IPL I–III, III–V, and I–V of Group 1 at 80 dB, 8 KHz were 1.62 (0.21), 3.54 (0.17), 5.45 (0.25), 1.82 (0.17), 1.96 (0.28), and 3.81 (0.38) (ms), and Group 2 were 1.71 (0.2), 3.69 (0.2), 5.72 (0.37), 2.05 (0.27), 2.09 (0.21), and 4.10 (0.37) (ms), respectively. Wave I was not affected ($P > 0.05$). Mean data were highly significant ($P < 0.001$) in Group 2 and wave III–V was significant ($P < 0.05$) [Table 4 and Figure 1].

Discussion

In the present study, waves of BERA I, III, V and I–III, III–V, and I–V interpeak latency were compared on the dominant right ear between BMI and age matched two groups [Table 1]. Waves III and V in Group 2 subjects were delayed. Hence, damage at the superior olivary complex and inferior colliculus may occur due to electromagnetic exposure.

At 4 KHz – A significant delayed waves III and V and I–III, III–V, I–V interpeak latency in Group 2 were recorded [Table 2 and Figure 1].

At 6 KHz – A significant delay ($P < 0.05$) of waves III, V, and III–V was found. Highly significant I–III, and I–V interpeak latency were reported in Group 2. A highly significant delay ($P < 0.05$) of wave III, III–V, I–III, and I–V interpeak latency and wave V in Group II as compared to Group 1 [Table 3 and Figure 1]. This is supported by Philip *et al*. study that reported high-frequency hearing loss detected by otoacoustic emission test in mobile phone users due to outer hair cell damage, particularly in the basal turn of the cochlea.[9] Kothari *et al*. study in medical students exposed to mobile phones also supported it.[10] A delay of 0.2 ms in wave V was also reported by Kellényi *et al*.[11] Absolute latency of waves III and I–V, III–V interpeak latency was delayed during mobile

Table 5: Brain stem evoked response audiometry waves and interpeak latencies comparison by Chi-square test at 80 dB and 8 kHz in mobile smartphone usage <5 years and mobile phone usage >5 years

Subjects	Subjects with normal brainstem evoked responses	Subjects with delayed brainstem evoked responses	Chi-square test
Group 1 (*n*=30)	24	6	*P*<0.00001**
Group 2 (*n*=30)	5	25	

P<0.001=Statistically Highly Significaant, **=Highly significant

phone electromagnetic experiment in rabbits reported by Kaprana *et al*.[12] Khullar *et al*. reported wave I–V latencies as well as interpeak latency were significantly delayed in groups using mobile phones.[13] Oktay and Dasdag[14] and Bhagat *et al*. study[15] did not support it.

Number of Group 2 subjects at 4 KHz, 6 KHz, and 8 KHz reporting abnormal brain stem evoked responses (delayed wave III and V latencies, I–III, III–V, and I–V IPL) was 60% (18/30), 70% (21/30), and 83.33% (25/30), respectively. The above results showed that as the stimulus frequency was changed from 4 KHz to 8 KHz, delayed brain stem evoked responses were recorded easily and found highly significant [Table 5].

Conclusion

The above findings suggest that apart from the deleterious effects of electromagnetic radiations on auditory systems in mobile phone users, BERA detects central nervous system involvement early if recorded at higher frequencies like 8 KHz.

Study implication

Avoid mobile phone usage for longer duration per day. It will definitely improve physiological and psychological activities.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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